NAVAL SURFACE WARFARE CENTER

Platform Motion Compensation (PMC)

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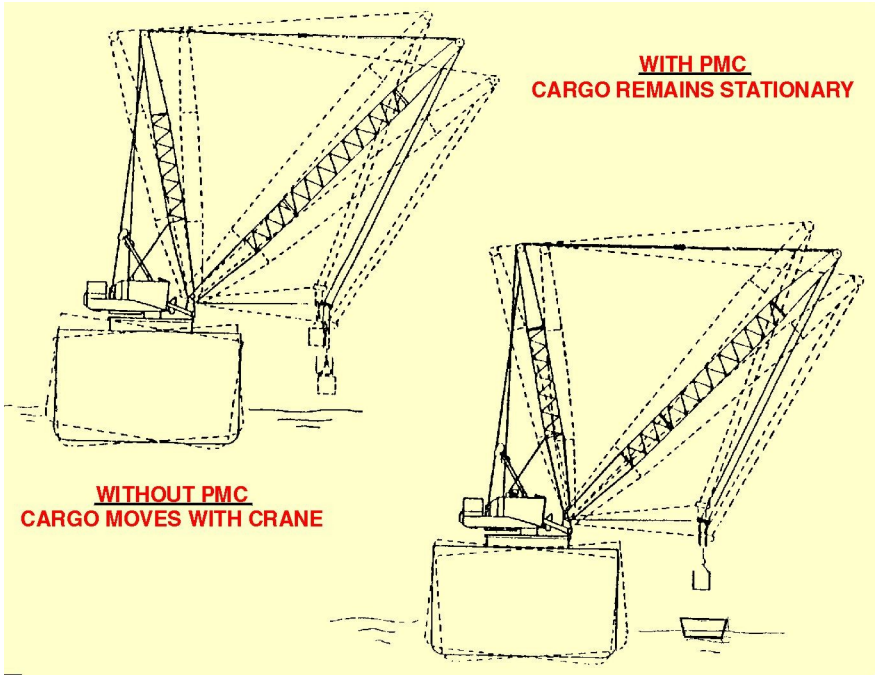


PMC Objective

Develop a system to compensate for the vertical motion of a load caused by own ship motion. (Relative motion between the ship and a lighter not addressed here).

The current Platform Motion Compensation (PMC) system uses existing crane machinery to compensate for the vertical motion of a load induced on the crane platform as the ship rolls, pitches and heaves during cargo handling operations.

PLATFORM MOTION COMPENSATION ON T-ACS CRANES

BACKGROUND:

- Original PMC was developed, installed and demonstrated on
  T-ACS 1 (KEYSTONE STATE) 8/84.
  - PMC algorithm was implemented with a separate (600HP)
    hydraulic winch.
  - Operational Testing of PMC was performed during J-LOTS II
    exercises 9/84.
  - This PMC system was effective but too costly.

- Current PMC design utilizes existing crane machinery to implement the PMC algorithm.

- Installation of current PMC on T-ACS 5 was completed

PLATFORM MOTION COMPENSATION ON T-ACS CRANES

PERFORMANCE:

- The current PMC is designed to fully compensate for vertical motion of a load up to 2ft/second and to partially compensate larger vertical motion excursions.

- The current PMC is integrated with the Integrated Rider Block Tagline System (IRBTS) previously installed and demonstrated on the SS FLICKERTAIL STATE

- The PMC and IRBTS form an interim system capability that is available now pending results of developments under the

MOTION COMPENSATION ON T-ACS CRANES

SYSTEM DESCRIPTION:

Effective Platform Motion Compensation (PMC) requires:

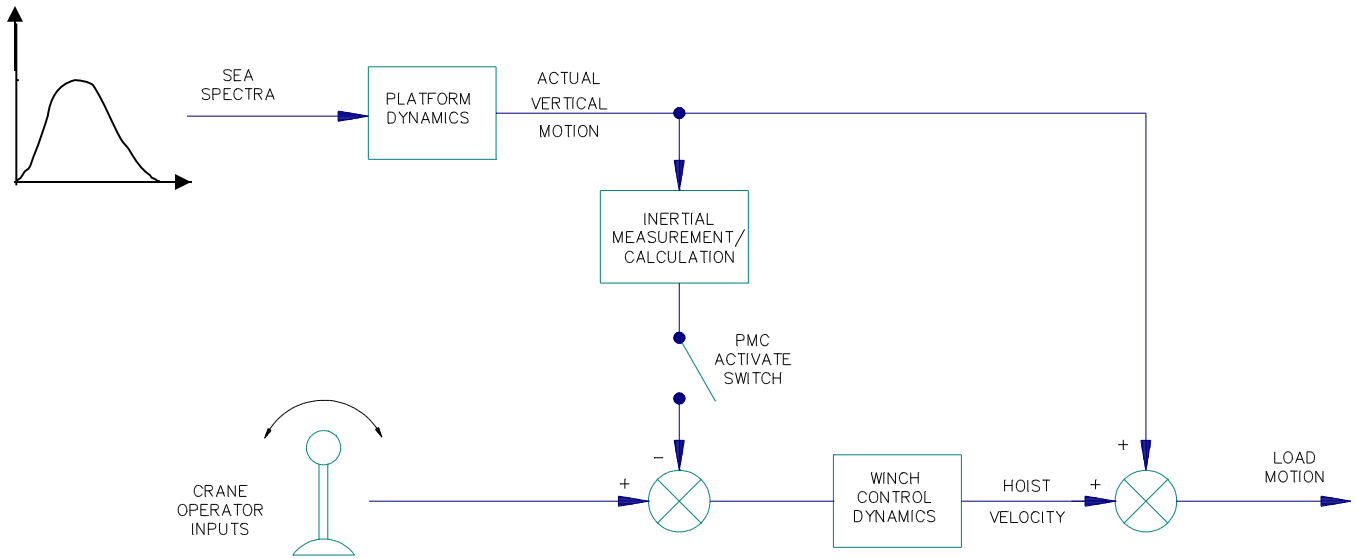
- Calculation of the vertical velocity of the load due to ship motion

- Activation of system by crane operator when compensation is desired

- Actuation of hoist to nullify calculated vertical motion from an inertial motion sensor

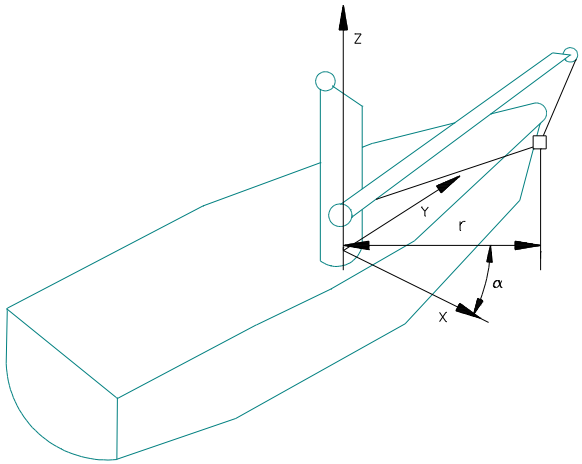
PLATFORM MOTION COMPENSATION ON T-ACS CRANES

PMC OPERATING SCHEMATIC



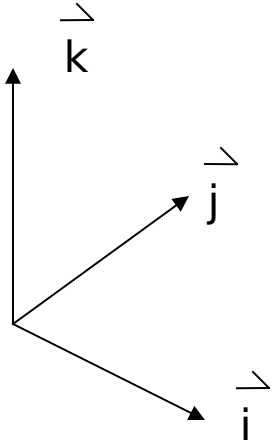
PLATFORM MOTION COMPENSATION ON T-ACS CRANES

VERTICAL VELOCITY CALCULATION DETAILS:



$$v = y\,(d\varphi/dt) - x\,(d\theta/dt) + (dz/dt)$$

where



$y = r \sin(\alpha)$,

$x = r \cos(\alpha)$,

r = load radius,

α = slew angle measured clockwise from the x axis,

$(d\varphi/dt)$ = pitch rate (about the x axis),

$(d\theta/dt)$ = roll rate (about the y axis), and

(dz/dt) = heave rate at the crane centerline.

PLATFORM MOTION COMPENSATION ON T-ACS CRANES

SYSTEM IMPLEMENTATION:

- The load radius is calculated using the crane geometry information from the Integrated Rider Block Tagline System (IRBTS) computer.

- A slew angle sensor was added to the ring gear of the crane's pedestal to provide slew angle.

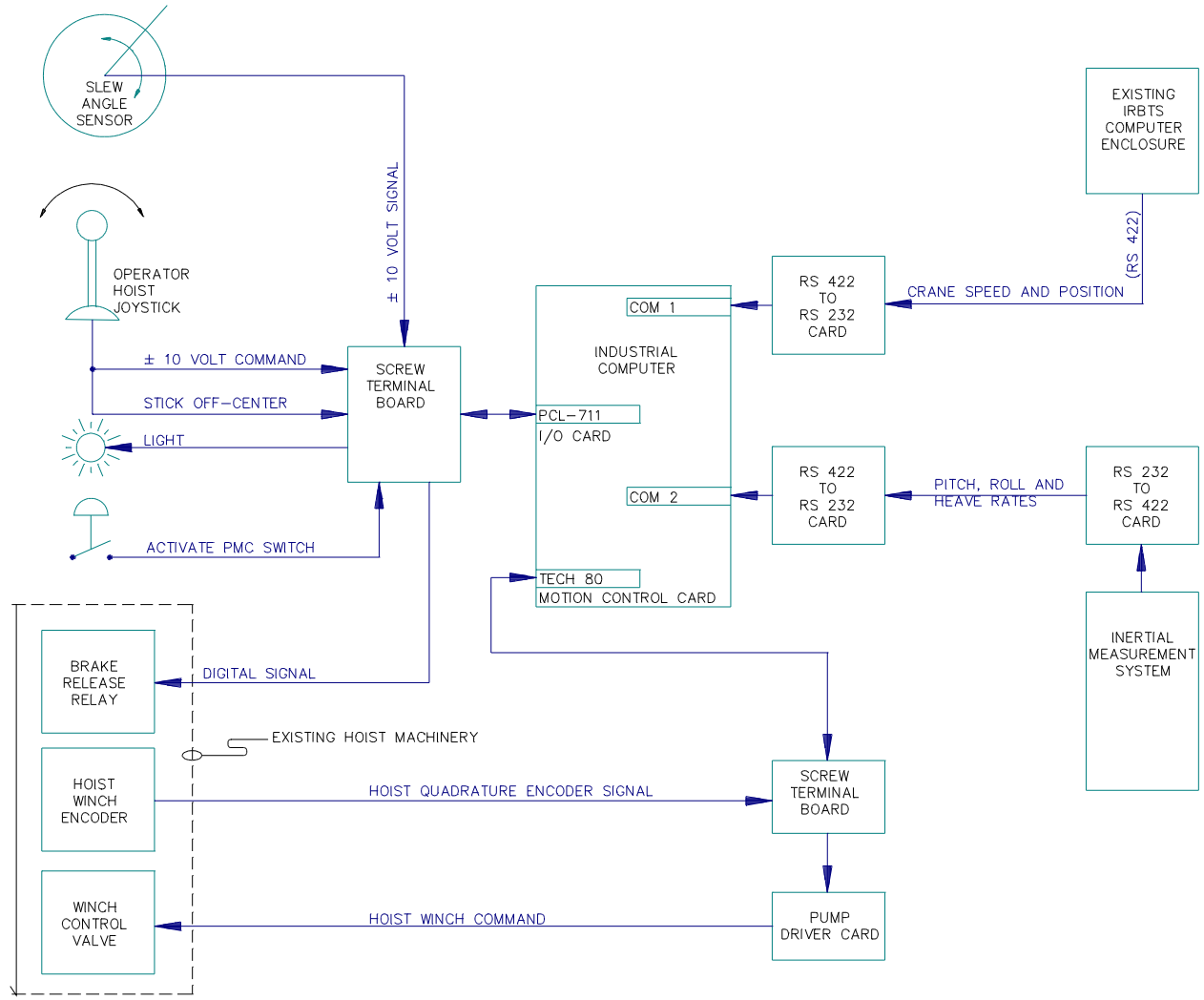
- An inertial measurement system was installed in the crane twin pedestal to provide pitch, roll and heave rates to the PMC computer.

PLATFORM MOTION COMPENSATION ON T-ACS CRANES

SYSTEM COMPONENTS:

- PMC electronic controls
- Dynamic Motion Sensor
- Crane slew angle sensor
- PMC activate switch and indicator
- Data link from IRBTS computer
- Existing hoist equipment on ship

PMC SYSTEM BLOCK DIAGRAM



PMC STATUS: Sept 00

- Completed feasibility system design
- Successfully completed hoist winch control interface tests, May 00
  - Crane response sufficiently fast for PMC needs
  - Test results usable for SS-3 crane ATD
- Demonstration successfully completed on 6 Sep 00
- PMC Design Report completed 21 Sep 00
- Demonstration Report completed
- Drafted Operating and Maintenance Manual
- PMC algorithm may be used on sea state 3 ATD crane

DEMONSTRATION RESULTS

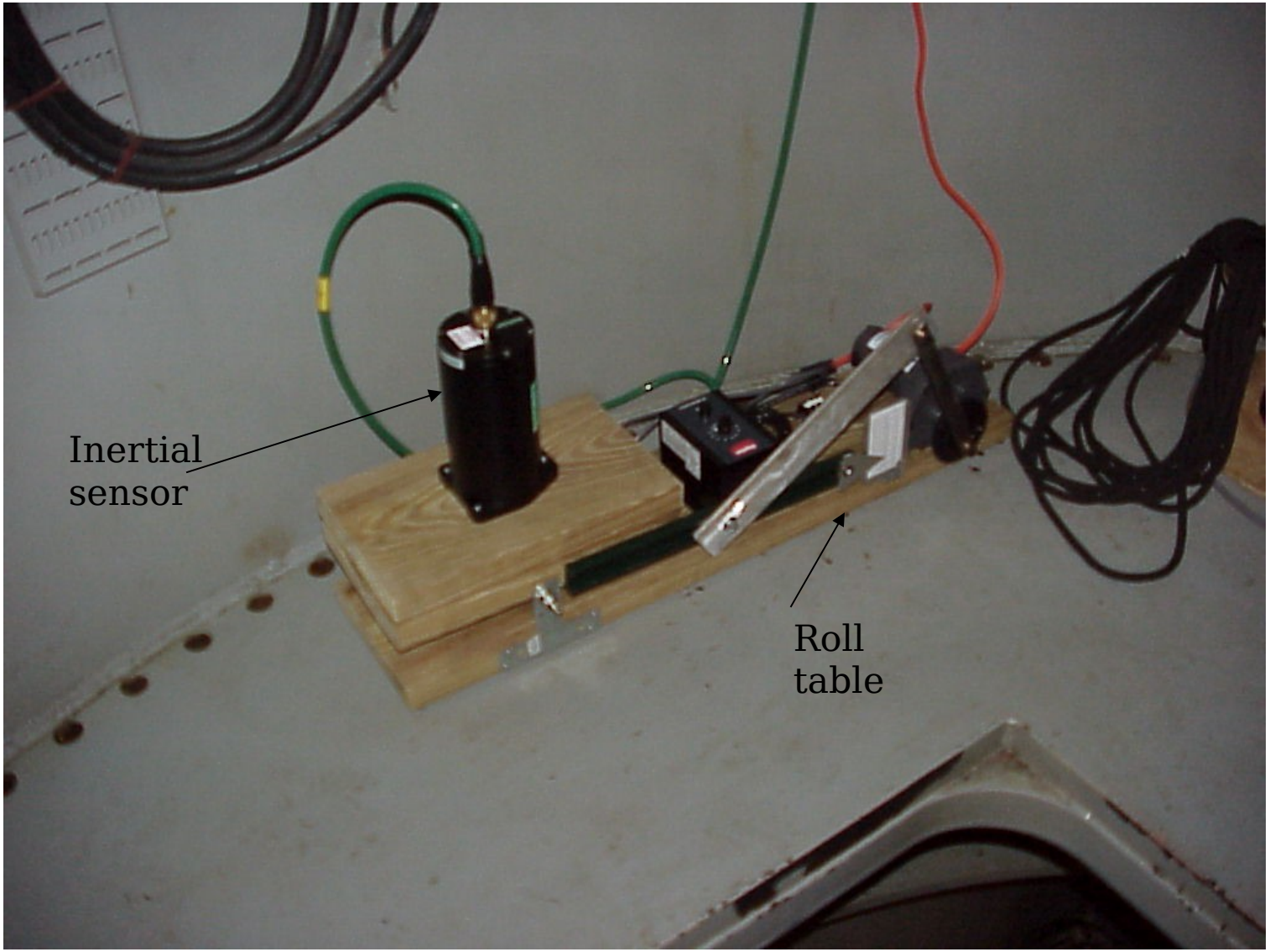
- PMC was successfully demonstrated
- Crane Hoist response was reduced
- PMC and IRBTS were successfully operated together

FY01 Plan

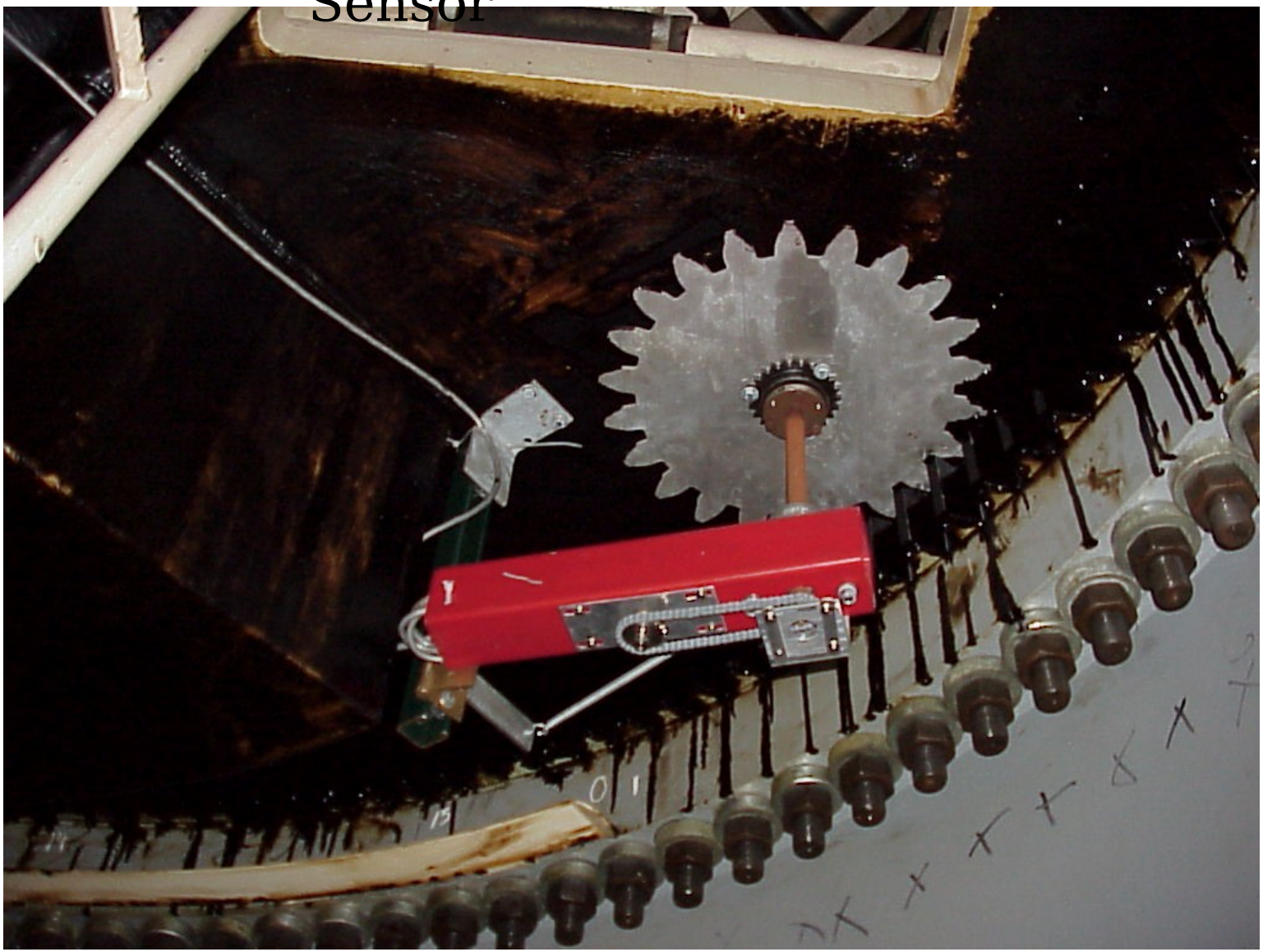
- Complete documentation including O&M manual
- Install a second PMC on the T-ACS 5
- Obtain ABS approval of design and installation
- Perform a comparison test during a JLOTS operation with and without PMC and IRBTS; compare results
- Final documentation

PMC ROLL TABLE

(Simulates roll)



Slew (Azimuth) Angle Sensor



PLATFORM MOTION COMPENSATION ON T-ACS CRANES

TEST / DEMONSTRATION OBJECTIVES:

In order to demonstrate the operation of the PMC, the crane was be placed at various orientations relative to the ship, while various motion periods, amplitudes and directions were simulated.

The Dynamic Motion Sensor was temporarily mounted on a roll table which simulated roll, pitch, or a combination of both.

PLATFORM MOTION COMPENSATION ON T-ACS CRANES

TEST / DEMONSTRATION INSTRUMENTATION:

A linear position transducer was mounted to the deck of the ship, below the hook, and data from the transducer was recorded to document the excursions of the hook due to PMC compensation.

The roll table, temporarily located in the turntable of the twin pedestal crane, had an inductive proximity sensor mounted to provide the frequency and phase of the